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Sensitivity Analysis of Coupled Groundwater Processes within a Land Surface Model

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Sensitivity analysis of coupled groundwater processes within a land surface model.

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Management of surface water quality is often complicated by interactions between surface water and groundwater. Traditional Land-Surface Models (LSM) used for numerical weather prediction, climate projection, and as inputs to water management decision support systems, do not treat the lower boundary in a fully process-based fashion. LSMs have evolved from a leaky bucket to more sophisticated land surface water and energy budgets that typically have a so-called basement term to depict the bottom model layer exchange with deeper aquifers. Nevertheless, the LSM lower boundary is often assumed zero flux or the soil moisture content is set to a constant value; an approach that while mass conservative, ignores processes that can alter surface fluxes, runoff, and water quantity and quality. Conversely, models for saturated and unsaturated water flow, while addressing important features such as subsurface heterogeneity and three-dimensional flow, often have overly simplified upper boundary conditions that ignore soil heating, runoff, snow and root-zone uptake. In the present study, a state-of-the-art LSM (CLM2.0) and a variably-saturated groundwater model (ParFlow) have been coupled as single model, in single-column and distributed form.

An initial set of single column simulations based on data from the Project for Intercomparison of Land-surface Parameterization Schemes (PILPS) and synthetic data demonstrate the temporal dynamics of both of the coupled models. A 15-year single-column simulation using the data from the Usadievskiy catchment in Valdai, Russia demonstrate the coupled model's ability to accurately predict the soil moisture profile and location of the water table, in addition to water and energy balance within the watershed. The distributed coupled model will also be demonstrated using a series of spatially variable subsurface parameter runs, which will be used to investigate upscaling in land-surface models. The coupled model will ultimately be used to assist in the development of Total Maximum Daily Loads (TMDLs- a surface water quality standard) for a number of pollutants in an urban watershed in Southern California in the United States.

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